CLUTCH TUNING HANDBOOK

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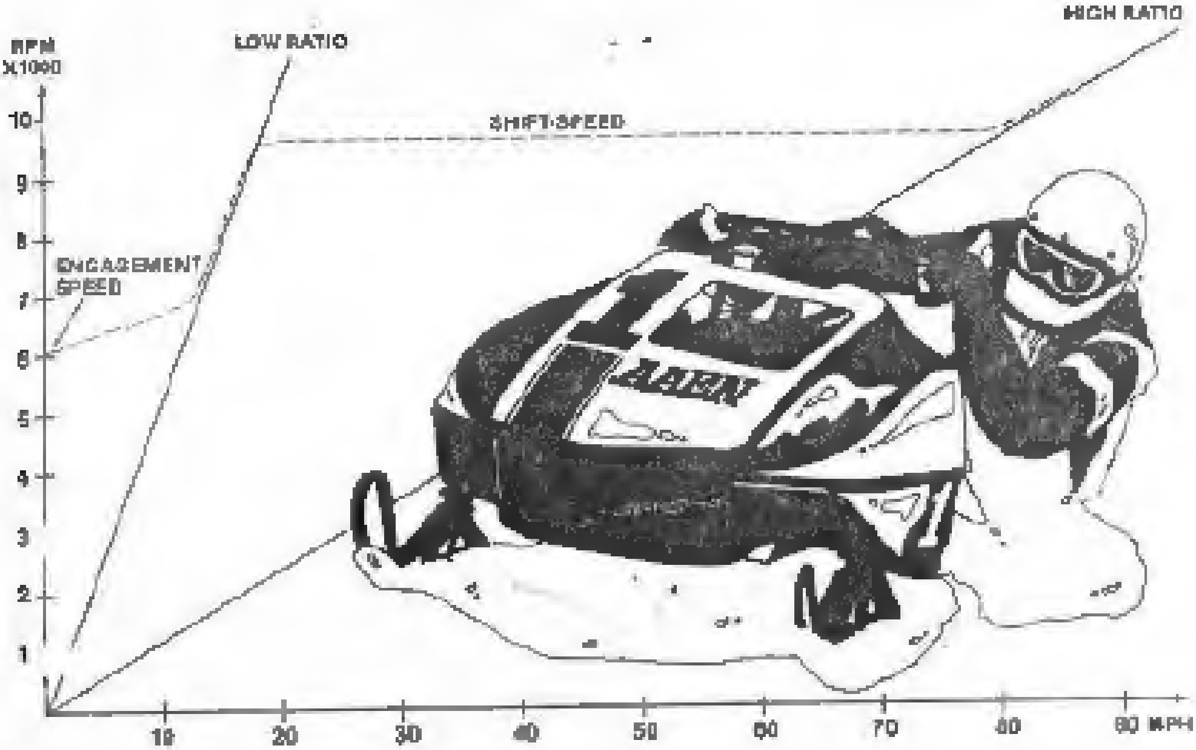


FOR THE SERIOUS RACER AND ANYONE WHO WANTS MORE PERFORMANCE FROM THEIR SNOWMOBILE BELT-TRANSMISSION

Information & Illustrations Courtesy Of:
Arctic Enterprises
Bombardier Corporation
Comet Industries
Kawasaki Motors
Polaris Industries
Yamaha International

Special thanks to Terri & Coe

Introduction

The Automatic V-Belt Transmission is one of the most important parts in the performance of your Racer. It is the vital link in a vehicle that constantly changes speed powered by an engine which ideally should be operated at a constant speed. With the narrow power bands of the modern two-stroke racing engine, it is important that the engine is kept on the power peak and that the power is transmitted in the most efficient manner for maximum performance.

The modern V-belt transmission is, in spite of its mechanical simplicity, controlled by a number of interdependent variables, and it is only by matching these variables that the best performance is obtained from the vehicle. The purpose of this handbook is to explain the function of the transmission and the variables that influence its performance and efficiency, and to give you a testing procedure that will enable you to match your transmission to your racer's requirements. There are very few things the factory racers do, that you could not do yourself with a good tachometer, and a sound testing procedure. The two ingredients necessary to obtain an efficiently matched clutch are an understanding of the mechanism and plenty of testing.

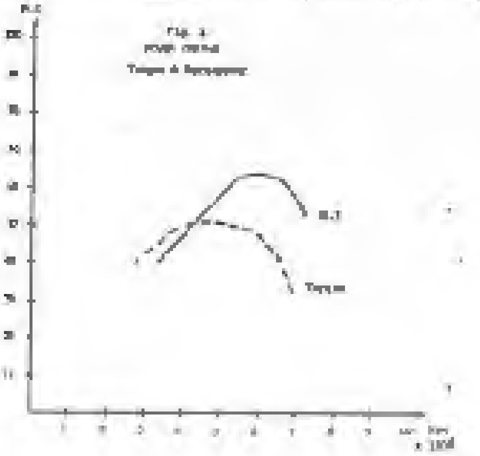
In this second and expanded edition we will go into further detail in the technical theory areas than in the previous edition. This may be a little too complicated for the beginner, but as you get further into the tuning of clutches and start looking for those extra percentages that make a winner, you will start to look into these areas and the theory may make more sense at that point. We are going into extensive detail in tuning popular clutches in the appendix and this should give the answers to most of the important questions on these models.

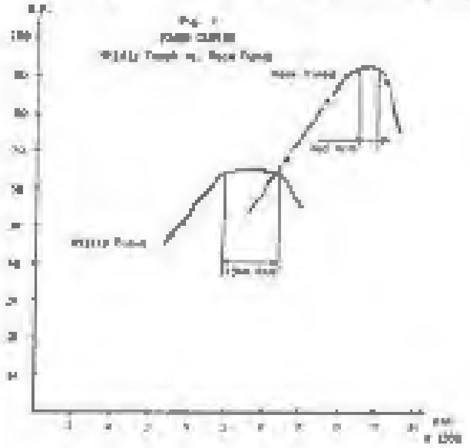
Power curves

The type of power your V-belt transmission is asked to transmit, has a large influence on the design of your transmissions component parts. Modern snowmobile engines are almost without exception, of the two-cycle variety with two or more cylinders. A V-belt transmissions function is to let the engine work at its power peak while the transmission changes the shift ratio as the speed of your vehicle increases. Depending on the shape of your powercurve, this may be accomplished with ease and consistency in a stock machine with relatively low power and a wide powercurve, or it may require the constant attention of a race mechanic in a high-strung race engine with high peak power and a narrow powerband. While most clutches work good with the wide powerband, it should be apparent as you go through this book that certain requirements are necessary to make a good race clutch.

Power in a two-cycle engine is a combination of the cylinder filling and the efficiency with which the combustible air-gas mix is burned in the cylinder. This produces the force on the piston which results in a momentum on the crankshaft referred to as torque. The more times this torque is produced in a given period, the more power is available. As the engine speed increases, the HP also increases until the engine goes beyond a point where it "runs out of breath." The cylinder filling and combustion efficiency then drops. When the torque production starts to drop faster than the speed increases, the resulting power will start to decline, and the engine will "fall off the power peak" as the RPM increases. In the example in Fig. 1, the torque or cylinder efficiency reaches its peak at 5,000 RPM. As it only drops off slowly to start with, the engine still peaks at 6,000 RPM before the power falls off. This represents a mildly tuned engine which would be easy to tune a transmission to. We will refer back to this curve on several occasions in future chapters.

In Fig. 2, we show the difference between a mildly tuned motor and a highly tuned racemotor of the same displacement. While the mildly tuned motor has a 1,500 RPM range in which the transmission can operate without too much change in performance, the highly tuned engines transmission has to operate within a 3-400 RPM range, and also at a much higher speed.





It becomes obvious that if an engine has been modified and the powercurve changed, the transmission has to be re-calibrated. There are many variables that control this calibration, and the object of this book is to enable you to obtain enough of an understanding of how a modern V-belt transmission works that you can perform the necessary changes to obtain maximum performance from your machine.

Speed Diagrams

Speed diagrams are powerful tools in understanding what happens to the transmission in your racer. By watching your dash and comparing it to the ideal diagram, you will be able to determine what variables to change to obtain maximum performance from your transmission. The diagrams are fairly simple to understand, as they explain everything in terms of vehicle speed and engine speed, the two functions your transmission attempts to control.

Fig. 3 shows such a diagram, with the vehicle speed in MPH on the horizontal axis, and the engine speed in RPM on the vertical axis.

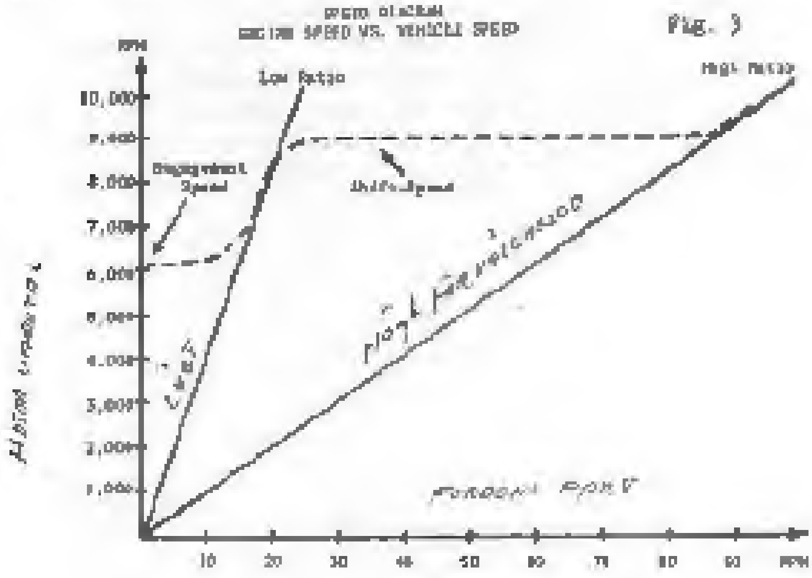


Fig. 3

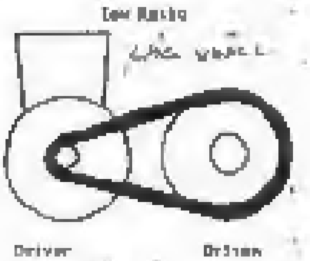


Fig. 4

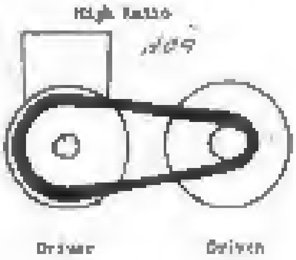


Fig. 5

The normal V-belt transmission consists of two sets of sheaves connected by a V-belt. The driving sheaves are mounted to the engine, and the driven sheaves are mounted to a shaft which drives the tracks or wheels of your racer through a chain. When the belt is at the smallest radius on the driving sheaves, and at the largest radius on the driven sheaves, the transmission is in low ratio, or low gear, which is usually around 3:1. This ratio is shown on Fig. 3 as a diagonal line. To the right of this line is another diagonal line but at a smaller angle, which represents the high ratio. High ratio, or high gear, occurs when the belt is at the largest radius on the driving sheaves, and at the smallest radius of the driven sheave, which is usually an "overdrive" ratio of around .8:1 (Fig. 5). While you are racing, the belt will constantly change position between these two ratios, and the correctly matched drive will keep the engine speed constant at the power peak (9,000 RPM as shown on Fig. 1), while the vehicle changes speed. The overall ratio of the drive is the low ratio divided by the high ratio; in the case of our example it becomes 3/.8 = 3.75.

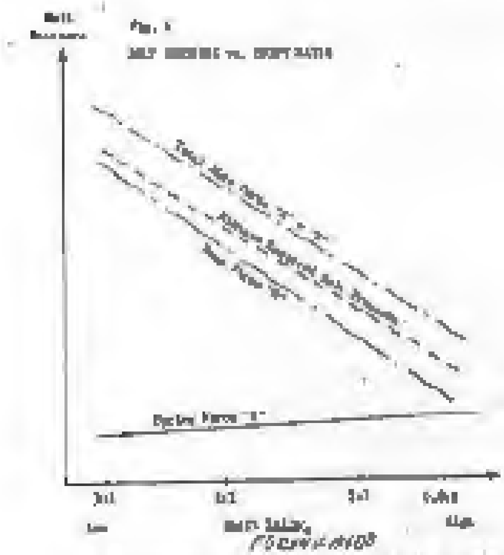
Fig. 3 shows the shift curve of a typical racing engine. The clutch engages at 6,000 RPM and clutches by gripping constantly harder around the belt until the belt is fully engaged in low gear (13 MPH on the graph). With the belt still in low ratio, the engine speed will quickly increase until the power peak at 9,000 RPM, when the centrifugal weights will overcome the spring force and torque feedback in the driven clutches and start shifting the belt while keeping the engine speed at the powerpeak. This is then the ideal shiftcurve on the speed diagram for this engine. After some practice, this diagram will become very useful and give a good understanding of how your transmission works.

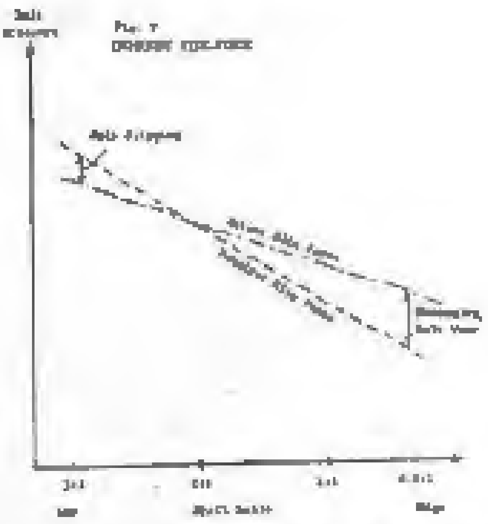
The next question is: how do we make the transmission work in this ideal manner, while minimizing the power losses through the transmission? To do this, we have to look at the variables that control the movement of the driven and driving sheaves and therefore the belt position at any time.

Efficiency

The secret to good efficiency lies in the driven sheaves, because their adjustment determines the power losses of the transmission. This may be surprising to some since most of the time is spent working on the driving clutch to match up the transmission but all work on the driving clutch is wasted unless you first have a setting on the driven clutch that will give you a good efficiency and minimum belt wear. Good efficiency is obtained when the side forces on the belt are large enough to transfer the power at any belt position, without slipping the belt. Tighter settings will produce losses from elastic stretch in the belt, and also make it more prone to wear and break. Of course, the bigger and more powerful your engine is, the more side force is required to transfer the power.

Fig. 6 shows the basic forces required on the belt by the driven sheaves for efficient power transmission. The dotted line represents the minimum force required to transmit the torque from a given engine. The higher the power of the engine, the further up on the graph the line would be, but the slope of the line would stay about the same, as it is determined by the shift ratio. The actual requirement does not end up as a nice straight line as in the graph due to changing efficiency through the shift range, but this is a little too complicated at this stage, and we will come back to this point later.





To produce a total force that is higher than the dotted line becomes the job of the torque ramp and torsion spring in the driven unit. The total force is a combination of the two forces. As the torsion spring gets tighter and provides more pressure as the drive shifts out, this is clearly a tendency in the wrong direction. To compensate, the ratio between the angles on the torque ramp and the radius at which they work produces a force with a slope that, combined with the spring force gives a total force slightly more than the minimum required to transfer the power and with a slope paralleling that of the minimum requirement line. (Maybe you should read that a couple of times). When this is obtained, as in Fig. 6, the drive will work efficiently through the whole range. In Fig. 7 is shown a condition that is far from ideal. Here, the force is too low to begin with, and too high at the end. The result is that the belt may spin slightly to start with and has too much tension in high gear, resulting in loss of efficiency and excessive belt wear. In this particular example, the culprit is a spring with too much rate and too little pre-tension. By increasing the pre-tension you'll get rid of the slipping, but will have even more belt wear and poor efficiency in the high ratio. The correct solution would be to install a different spring with less rate, and use this with higher pre-tension (dotted line). Good efficiency is the result of a well engineered driven unit with the correct combination of spring rate, tension, and torque ramp angle.

Here is where it pays to keep a good eye on the factory racers. It is usually easy to see what ramp angles they are running, and by hanging around when they change belts, you can get a good idea of the pre-tension by watching the effort required to spread the sheaves. Sometimes they may even tell you if you ask, but don't take all information for granted-- it pays to check several fast machines to get a good idea of the settings.

In the back is a data sheet for your use during the clutch-tuning procedure. Be sure to keep a record of the ramp angle and pre-tension on your driven clutch.

The Driven Sheaves

Since the torque is multiplied in low gear, most side force is required when the belt rides at the largest radius of the driven sheave, and least side force is required when the belt is at the smaller radius, or in high gear. This is hard to accomplish with springs alone so the torque-sensing ramp was introduced.

The torque-sensing ramps work against the moving sheave, and feed part of the torque back as side force on the sheaves, and therefore automatically adjusts the side force requirements on the belts as it changes position (Fig. 8). They are usually interchangeable and available with different angles for varying amount of torque feedback. The smaller the angle, the more side force is created against the belt. Engines with 75 - 100 HP usually run 30 - 35°, while smaller engines may run ramp angles up to 40 - 45°. If you only change ramps, a ramp with a smaller angle will bring the engine speed up before it shifts to compensate for the higher torque feedback. A larger angle will permit the drive to shift at a lower engine speed.

The spring in the driven unit is present to give a pre-tension to the ramps so that the necessary side force is available to transfer enough power in low gear to give an initial

Fig. 8

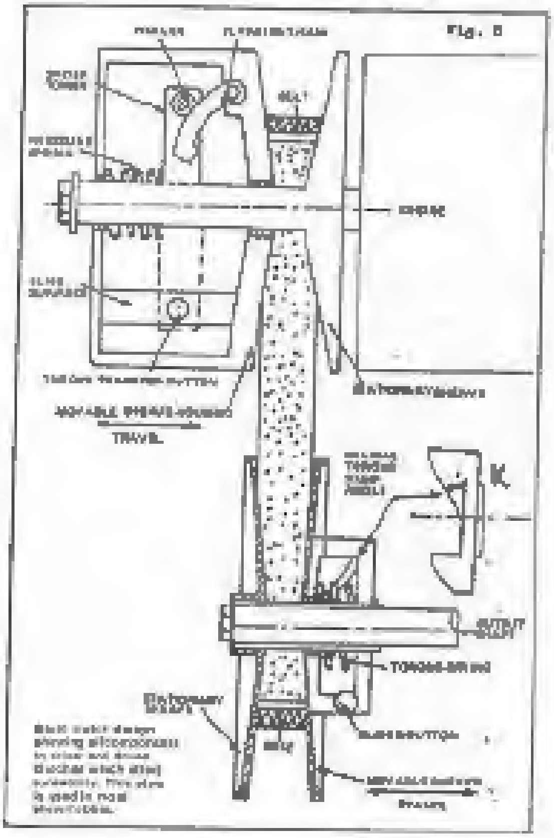
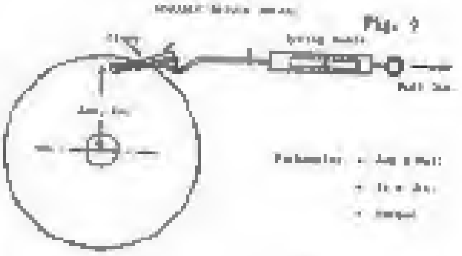


Fig. 9



start for the torque-sensing to work. Required pre-tension is usually around 50 – 100 inch-lbs. as measured on the movable sheave, and there are usually several holes available in the hub to give your spring the correct pre-tension. You can measure the pre-tension by attaching a clamp to the movable sheave at a given radius and pull with a spring scale until the torque ramp moves away from the slide buttons. The scale must be at right angles with the radius (see Fig. 9) and you then multiply the radius with the pull on the scale to get your setting in inch-lbs. Increasing the pre-tension will bring the engine speed up before the drive starts shifting, and decreasing the pre-tension will permit the drive to shift at a lower engine speed. The tuning should not be done with the driven components to correct the engine speed, only attempt correcting slipping or excessive belt wear. Too little pre-tension and too large ramp angle will make the belt slip, while too much pre-tension and too small a ramp angle will cause increased belt wear. Keep track of the ramp angle and pre-tension for reference during testing. Usually the recommended ramp angle and pre-tension will be given to you by the manufacturer of your machine but sometimes this may not be the latest information.

DRIVE EFFICIENCY CURVE

The typical efficiency of a belt drive transmission is shown in Fig. 10. As the belt starts out in low gear, it has to make a relatively tight turn around the shaft while there is also relatively small contact area. Combined with the fact that this occurs at the same time that maximum belt pressure is required results in bending forces and distortion on the belt which steals power and reduces efficiency.

As the belt shifts out, it starts running at larger radiuses and the pressure is less. Efficiency then increases until the belt goes past the 1 : 1 range. Now the belt speed has increased considerably as it moves out on the driven sheave. The more times the belt has to bend in a given time, the more power is lost. As the speed increases, the belt also has to turn around a tighter radius on the driven sheave. As a result, when the drive goes into overdrive, the efficiency falls off again. Attention to detail in this area can give quite a gain in top end. It is doubly important not to have too much side tension in high ratio, as this would only lead to more power loss and less top speed.

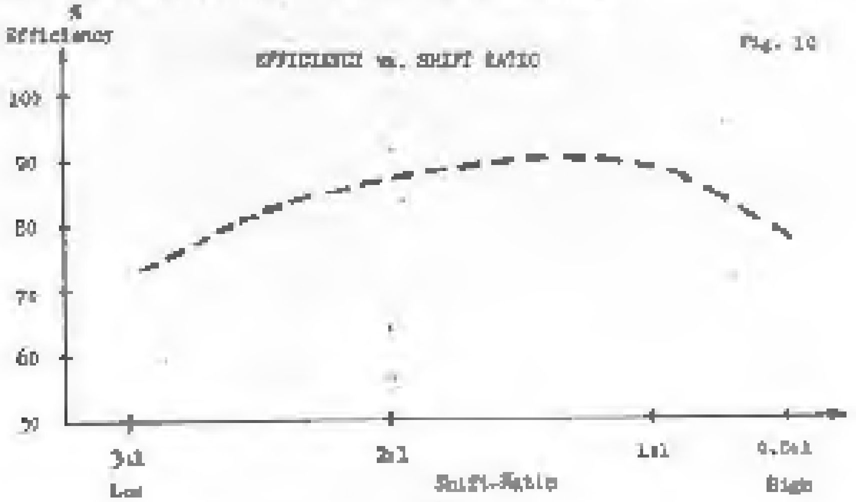


Fig. 10

The Driving Sheaves

While the correct design and adjustments on the driven sheaves determines the efficiency of the transmission system, the driving sheaves must control the engine speed and keep it running on the power curve through the entire shift range. When both systems function correctly and give maximum horsepower coupled with best efficiency, you have a correctly tuned clutch.

The movement of the sheaves and the belt is controlled by flyweight and cam-mechanisms in different arrangements from one design to another. Much of the "tunability" of the clutch system depends on the design of this mechanism and there are advantages and drawbacks to all of them. Basically the systems have to overcome the forces of the pressure spring, and then match the side pressure requirements of the driven plus the torque lost in transmission between the driver and the driven system. The net force required is therefore larger on the driver than on the driven.

To understand the influence of the parts in the driving clutch we should take a look at the jobs the driving clutch has to do. First, the clutch permits a free-running condition which is the engine speed below engagement, to make it possible to start and warm up the engine while the machine is stationary. In the free running condition, the force from the pressure spring is stronger than the force from the centrifugal weight and roller-mechanism, and the movable sheave will therefore not close on the belt.

At a certain engine speed, usually called the engagement speed, the force from the centrifugal weight mechanism will overcome the spring pressure, and the movable sheave will close in on the belt and start to engage it. The vehicle will start moving as the sheaves close harder around the belt until it is fully engaged and no more slip occurs. This is called the "clutching action" and takes place up to 30 MPH depending on engagement, speed, and gearing. The belt is still in the low ratio position in the sheaves, and the engine speed will now increase until the shift-speed is reached. At the shift-speed, the centrifugal forces overcome the tension of the driven sheaves and moves the belt on the driving clutch sheaves.

In a correctly tuned clutch, the shift-speed is at the power peak of the engine and the engine now maintains a constant speed while the belt changes position to increase the vehicle speed.

The point where the belt starts moving out is critical, because until that engine speed was reached an increase in force from the centrifugal mechanism was necessary. But when the belt starts moving out less side force is necessary on the belt to shift it because the torque-sensing mechanism on the driven sheaves feed less side force into the belt as the torque multiplication is reduced when the ratio changes from low gear.

Since the engine is required to stay at a constant speed, the reduction in force can only come from the shape of the flyweight surface working against the rollers in the case of

the Polaris, Comet, Yamaha and [illegible] clutches or the shape of the shift-cam which the flyweight rollers work against in the Arctic and Ski-doo clutches.

The shape of the cam surface then determines how well the side forces on the driving sheaves match with the side forces on the driven sheave and thus determines how "straight" the drive shifts, i.e. how close to a constant speed the engine is kept.

If the transmission does not shift straight, you will be off the power curve at some point in the shift cycle, with a loss in performance as a result. There has been exception to this in cases where it has been desirable to let the engine over-rev temporarily and then shift out at a later point, but the purpose of this is mainly to compensate for bad traction or extremely narrow power curves.

Driving Clutch Components

Pressure Spring

This spring is located around the shaft and spreads the sheaves apart to obtain the free running condition. (See Fig. 8) The installed tension of this spring determines the engagement speed of the transmission. For highly tuned engines a high engagement speed is necessary because the power falls off quickly at the lower RPM. The higher the installed tension of the spring, the higher the engagement speed. When you change to a spring with higher pressure to increase the engagement speed, the shift speed will also move up, but not in the same proportion as the increase in engagement speed. A stronger spring that moves the engagement speed up 500 RPM may only move the shift speed up 100—150 RPM due to the nature of the centrifugal weights which increase pressure at a rate which is a function of the square of the engine speed. It is important to keep track of which spring you are using, and what engagement speed it gives you combined with your flyweights. This information is generally available from the manufacturers, and should be kept for reference when you start tuning the clutch.

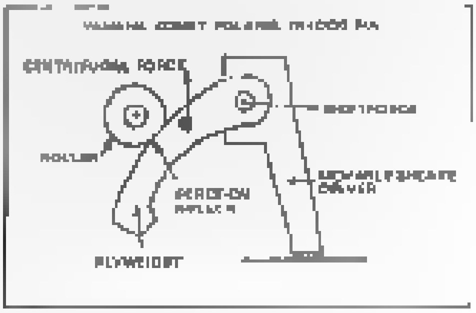
Some springs may take a set and provide less tension after some use. This will lower the engagement speed and shift speed. Rather than changing springs whenever they take a set experienced racers will retune the clutch by taking some weight off the flyweights and use the spring that has already taken a permanent set. Some racers also put new springs in a vise and compress them fully several times to make sure that the spring takes a set before they use them. On newer designs this may not be a problem anymore, but it does not hurt to check overall length of your spring whenever you have the clutch apart to see if it has taken a set.

Flyweight Systems: Polaris, Comet and Yamaha

These driving clutches are basically of the same principle as far as the flyweight arrangement is concerned. Three flyweights are mounted directly on the movable sheave and work against rollers mounted on a "spider" which is fastened to the drive shaft. Movement of the belt is controlled by the weight and shape of the flyweight. The distance of its center of gravity from the center line of the drive shaft and the speed of the engine produces a centrifugal force on the flyweight. How much of this centrifugal force that is then turned into actual side force on the belt is determined by the shape of the flyweight where it works against the roller. (see Fig. 11)

It is important during testing to only change one variable at a time, otherwise you are sure to be confused after a while. Most manufacturers supply a series of flyweights that have the same shape but different weights. When changing flyweights with different shapes try to go to one with the approximate same weight. When changing flyweights of different weights only use the ones with the same shape. If you go from one flyweight with one weight and one shape, to another with different weight and different shape, you will not know how much of the change was produced by the shape of the flyweight and how much was caused by the weight of it.

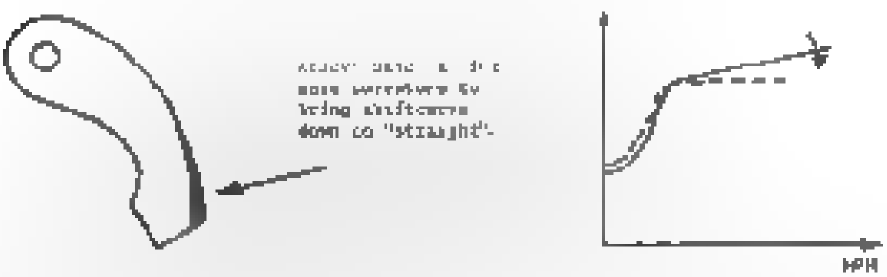
Fig. 11



Flyweight system employed in Yamaha, Comet, John Deere, Polaris [illegible] the contact surface of the flyweight

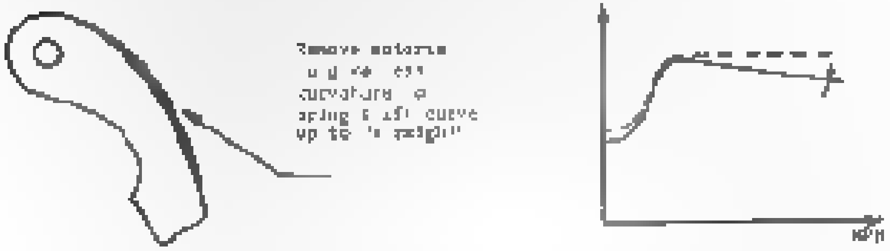
Fig. 2

Fig. 13



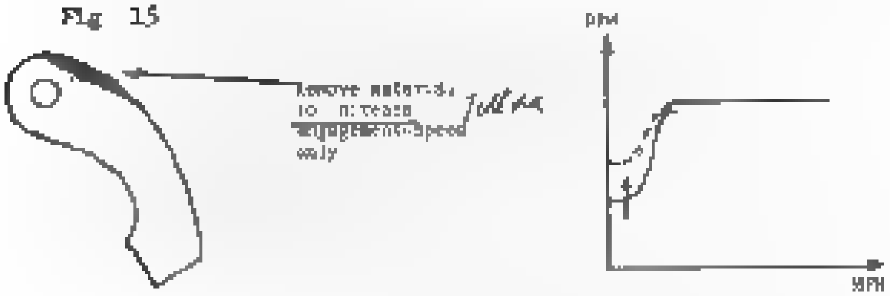
[illegible]
more curvature to
bring shiftcurve
down to "straight".

Fig. 14



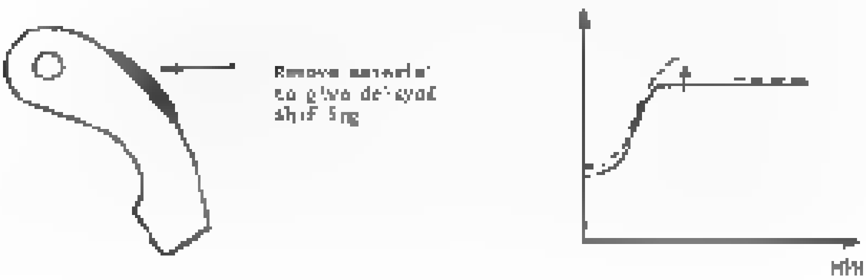
Remove material
to give less
curvature to
bring shift curve
up to "straight"

Fig. 15



Remove material,
to increase
~~engagement-speed~~ full adv
only

Fig. 16



Remove material
to give delayed
shifting

Influence of Weight

The weight of the flyweight is usually given in grams because this is the most accurate and easily understood system. The change in weight is then directly proportional with the number. Going from a 40 gram weight to a 44 gram weight gives you a 10% increase in the weight.

A heavier weight will bring the engagement speed and shift speed down, while a lighter weight will bring the engagement speed and shift speed up. If there is no flyweight available between two sizes to give you the exact shift speed you want, some weight will have to be removed from the heavier set of flyweights. This weight should then be removed from the backside of the flyweight in a small gradation at a time as shown in Fig. 12. Before installing the flyweights again, make sure they all weigh the same ± .2 grams, otherwise the drive will be out of balance.

The Yamaha clutch has a unique system of changing weight. Their flyweights have 3 holes in them. To increase weight, a rivet is added in the hole, increasing the weights until all three holes are filled. For closer details, look in the appendix under Yamaha clutches.

When the shifting surface is ground, it is important that all the arms are ground the same. If not, one arm may swing further out at any given shift position, and this will bring the drive out of balance. To make sure the shift surfaces are the same, the arms should be ground in a fixture that holds them all and then ground with a belt sander. The final weight should be checked on a scale, preferably of the three-beam design for accuracy.

Influence of Shape, Obtaining "Straight" Shift

The shape of the flyweight determines if you will have a straight shift. A straight shift holds the engine exactly on the power peak all through the shift range. To increase the engine speed in a given range, the flyweight should be given less curvature in that section.

Assuming your clutch was in good working condition and the driven cam angle and pre-tensions were right, but the engine started over revving as the drive shifted out, you would have to replace the flyweight with one with more curvature or grind the shift surface as in Fig. 13.

If the drive started to shift out at the right engine speed, but pulled the engine speed down as the drive shifted out, a flyweight with less curvature is needed, and if none are available, the existing weight can be ground as in Fig. 14.

Changing Engagement Speed

Sometimes there will not be a spring strong enough to give you your desired engagement speed, and the weight has to be modified to obtain the desired speed. This can be done by grinding as shown in Fig. 15.

Another way of changing the engagement speed is to let the flyweight rock under stop to move the center of gravity closer under the pivot pin. It should also be noted that this moves the shift curve if the sheaves are not readjusted to give correct belt clearance on engagement. See specifically under Polaris Race Clutch adjustments.

Overspeed with Delayed Shift Out

This modification will let your engine overrev before it starts shifting the belt and then shift down to the power peak later in the shift range. Drivers used this on their earlier stock racers to prevent the track from breaking loose on the start and give them [illegible] extra jump coming out of the corners. With the increased traction available with better suspension and studding, this particular modification is somewhat less used these days. To modify the flyweight, a flat is ground in the early portion as shown in Fig. 16.

Grinding Flyweights

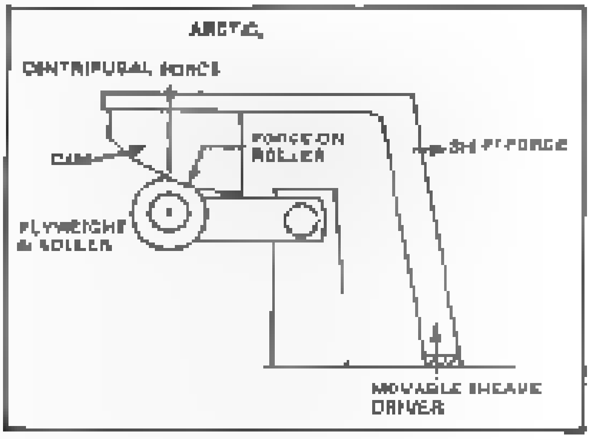
There are a few things to watch for when you start grinding the shift surface on the flyweight. You have to make sure that the finished surface remains flat and parallel with the pivot pin. If this is not the case, there will be bending moments and side-forces on both the roller and flyweights and the bearing surfaces will deteriorate and wear.

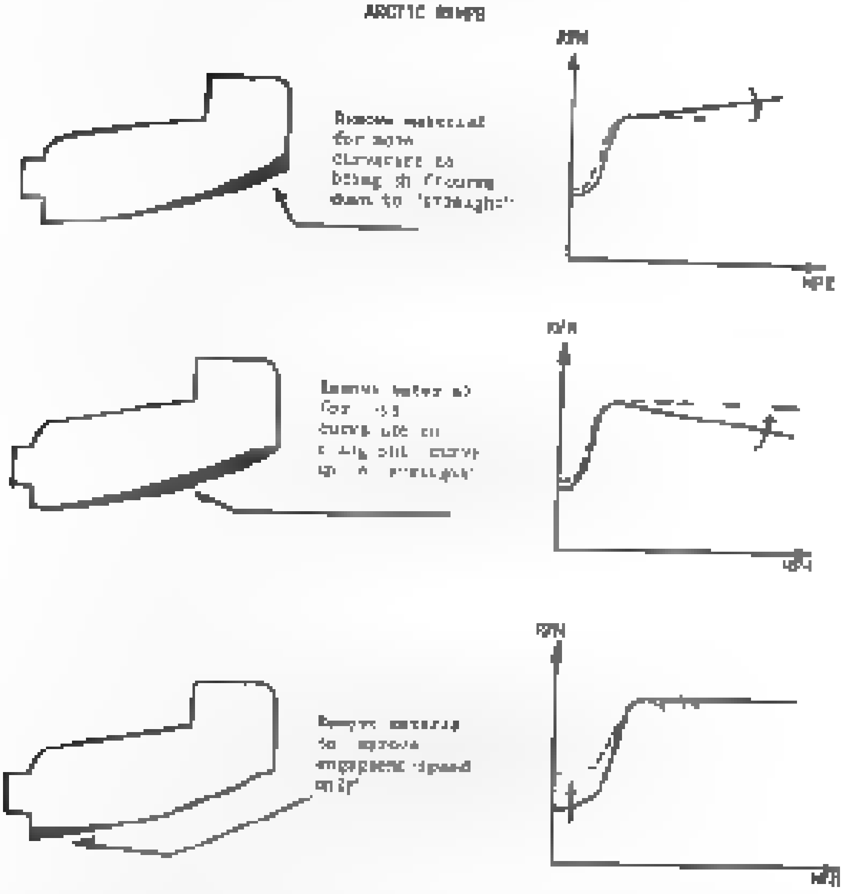
Also when the shift surface is modified, material is removed which makes the flyweight lighter and moves the basic curve up slightly. The changes in shape usually have more of an influence in the shift pattern than the weight that was removed, but it is a detail to consider because you are actually changing two variables at the same time.

Arctic Clutches

Everything that has been said so far about transmissions applies to the Arctic made except for their flyweight system. As [illegible] the reaction roller is on the flyweight and the shift cam is mounted on the moving sheave. The advantage of this arrangement is that the cam surface can be changed to give a straight shift without changing the weight of the flyweight. The flyweights can then be calibrated separately by adding washers to the roller pin to give an accurate shift speed. Rules for curvature of the shift cam also apply for the Arctic clutch. A large angle with the drive shaft will pull the engine speed down, while a small angle with the drive shaft will cause the engine to speed up. This applies for both engagement speed and shift speed. See Fig. 17. For more specific tuning information see the appendix.

Fig 17




ARCTIC RAMPS

Remove material for more clearance as being shifted down to "straight"

Remove material for less curve and or bring shift curve up to straight

Remove material to improve engagement speed only

Kawasaki Clutches

Kawasaki's clutch has an unusual design of the flyweight system. Rather than the weight arm starting in the 6 o'clock position and swinging to the 9 o'clock position as in Polaris clutches, the Kawasaki arm starts in the 9 o'clock position and swings to the 12 o'clock position. The weight arm has a bolt hole in which different bolts and washers can be mounted to change the weight of the arm. Engagement speed is easily changed by grinding the tip of the arm where it first contacts the roller. Modifying to higher speeds can be done by lighter arms, but since the curve of the arm is curving in instead of out it makes it hard to modify the shift curve itself. For more details on tuning the Kawasaki clutch see appendix.

Other Makes

There are a number of other makes of clutches, but the above mentioned clutches are the most popular for racing. If you should have a clutch that is not one of the makes mentioned the only difference will be in the flyweight mechanism. It is fairly easy to establish the weight position and the cam surface that controls the shift in any design by some study of the mechanism. Once you have established what the cam surface is and how to influence the weight of the mechanism, the same rules apply as in the mechanisms mentioned. If you understand the previous material in this book you should also be able to figure out how to influence a new design.

Rollers

The shift surface has to react against a roller to produce the desired force on the sheaves, and the rollers have to rotate freely to make the clutch shift come alright. Correct bearing design is therefore of great importance in a good working clutch.

Bearing materials vary from fancy needle bearing and teflon coated bronze/brass bushings to fiber bushings and plastic bushings and plain impregnated steel running against the steel pin. The higher the level of performance and the more critical the application, the higher the demand is on the roller bushings. Maintenance of the rollers is therefore of great importance. If the roller stops to roll, the flyweight arm will start to slide on the roller surface creating a flat spot. This will deteriorate the shift characteristics and harm both the upshift and backshift capability of the clutch.

Sliding Bearings

In order for the movable sheave to move and shift the belt, it has to slide on bearings or bushings on the clutch shaft. These bearings have to be correctly aligned and properly designed to give a smooth shift. In clutches where there are two bearings, one in the movable sheave, and one in the cover, these have to be correctly aligned to work freely and not

bind on the shaft. [illegible] Yamaha and [illegible] are [illegible] design. [illegible] makes use a particularly interesting design because both bearings can swivel in their housing, and there are [illegible] spring [illegible] design [illegible] for nicks and scratches on the sliding surfaces that will cause the bearings to wear prematurely. [illegible] bearings may give the sheaves a [illegible] and jam on the shaft or against the torque-buttons on the spider towers as the sheaves get thrown out of [illegible]. This will result in poor [illegible] characteristics. To check the condition of the bearings [illegible] all the [illegible], then reassemble the covers on the [illegible] the pressure spring in place. Move the sheaves in and out as they would during shifting and check for play or areas in which they would stick [illegible] the [illegible] should be checked if the sheaves show [illegible] in their movement.

Torque Transfer Point

As the sheaves move in and out during the shift the power or engine torque must be able to be transmitted [illegible] binding up the sheaves. In the [illegible] assembly the torque is transferred to the movable sheave through the torque [illegible] and the [illegible] buttons, and this is now a standard design on all units.

The driven assembly is a different story. There are a number [illegible] at the transfer of torque while the sheave is moving. On earlier models the sheave would move on a spline of the shaft which then [illegible] as the [illegible]. [illegible] there would be [illegible] forming on the [illegible] and the assembly [illegible] resulting in binding [illegible] are now only used [illegible] or clutches as new designs have proven more effective. The next step was to replace the splines with [illegible] square bushings [illegible].

Although these designs work well in most conditions, they partly suffer from the same problem as the splines. They serve two functions both as sliding bushings and torque transfer point. To make matters worse, the radius at which the torque is transferred is rather small [illegible] the force to be transferred large [illegible].

One of the first to [illegible] this problem was the Polaris engineers. They [illegible] to move the transfer radius as far out as possible and [illegible] the bushings to just take care of the sliding action. To accomplish this, they put [illegible] on the spider towers where the rollers were mounted. On each side of the tower the buttons [illegible] fine machined surfaces. Since the torque transfer point [illegible] the radius only one tenth of the force would work on the surface making it easy to slide and shift the sheaves. With the larger radius, the clutch is also less sensitive to wear on the sliding surfaces [illegible] and [illegible] have [illegible] sliding [illegible] on the [illegible] towers and this is a desirable feature for a racing clutch.

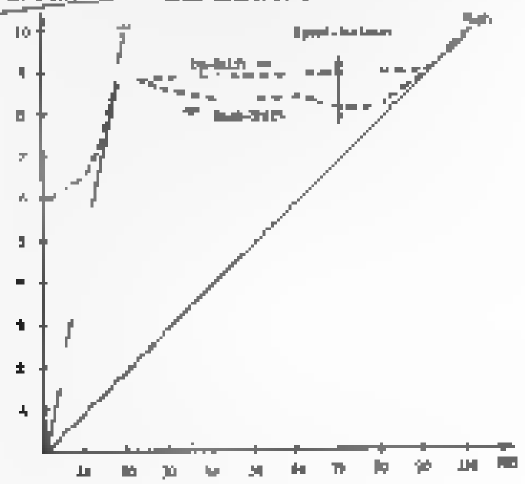
Back-Shifting and Speed Variance Curves

The true test of a good clutch comes when the clutch has to back shift in response to changing loads or speed. A race driver coming out of a corner, somebody starting to climb a hill or somebody hitting deep loose snow needs an accurate back-shift pattern. The clutch has to shift down and increase the shift ratio while maintaining the engine speed for full power. If the moving sheaves are binding when they try to shift back, the engine speed and power will drop and so will the speed of the machine.

There are a number of friction points in a clutch; rollers, flyweights, sliding bushings and torque transfer points all create certain resistance to back-shifting. A certain minimum amount of pre-tension is therefore needed to overcome this friction. As a clutch gets worn, there will be more friction and the clutch will start to perform poorly. It will drop quite a bit in engine speed before the unit reacts. As the friction also is present during the upshift it will require more RPM to overcome the forces. As a result there will be a difference in engine speed on up and down-shift, and this difference is called a speed variance curve, see Fig. 19.

A good clutch should not have a speed variance of much more than 250 RPM between up and down shift. The older clutches with splines and hex or square bushings are the most prone to develop a large speed variance as they get worn, and they wear faster because of the higher forces they need to transmit and the double function of the bushings. This may not be overly pronounced on a regular trail sled, but on a race sled it becomes the difference between winning and losing and for this reason the design with a torque transfer point on the spider tower is much preferable. An exception to this rule is drag-racing where no back-shifting is required and the Arctic hex bushing is most popular because of its few parts which allow quick fine tuning.

SPEED-VARIANCE CURVE Fig. 19



When back-shifting deteriorates, some drivers will respond by tightening up the driven sheave. This will not reduce the speed variance but rather move the back-shift curve closer to the power curve. This helps during back-shifting, but since the up-shifting curve now moves up and off the power curve on the backside, there is usually a reduction in performance and top speed. Bad back-shifting is a sign that the mechanisms are getting worn and that something is binding, and instead of wrapping the driven sheave tighter, the clutch should be serviced and the worn parts replaced with new ones.

Maintenance

It should now be clear that maintenance is the key to good clutch performance. Belt dust and other particles get in everywhere, bearings wear out and tolerances soon disappear. Any erratic shifting is a sign of something is binding somewhere and in the end it becomes a matter of routine to inspect and maintain the parts in good working condition.

Alignment

It is very important for performance and belt life that the sheaves are in correct alignment with each other and have the correct center distance. The alignment should be set up correct for the high ratio because this is where the belt speed is highest and where greatest whip does the most harm. If the engine is rubber mounted on the chassis frame, the alignment will change under load. To prevent this many racers mount a turnbuckle with two rod ends between the engine and the mounting for the cross shaft (see Fig. 29). The correct alignment figures are given by the manufacturer for their clutch.

Balance

Your driving clutch may reach speeds of 12,000 RPM, and your driven clutch even higher, and small amounts of unbalance may affect the performance and cause severe loads and loss of efficiency. It is therefore important that all parts are balanced as closely as possible.

Most driving assemblies have marks on their components so that they can be assembled in the same relationship each time to keep the balance correct. [illegible] the balance may be changed as when for instance the sheaves are machined true. Some sheaves have cast surfaces that may vary due to die-wear, and these sheaves should then be machined true. This will change the original balance, and the parts should be rebalanced. This can be done mechanically with a wheel-truing stand or other balance stands such as used for crankshafts. Unbalanced clutches often result in poor shifting, premature wear, and sometimes broken or bent crankshafts.

Correct Inertia

This is a phenomenon many tuners are not aware of. Each engine has a natural [illegible] frequency in the crankshaft assembly depending upon the flywheel [illegible] of the shaft itself and all the parts mounted on it. A natural frequency is what a tuning fork vibrates at when struck against an object. If the natural frequency of the crankshaft happens to occur close to the power peak of the engine where the clutch has to operate, the result can often be disastrous with clutch parts wearing at astronomical rates and even crankshafts breaking. This often occurs when other than an original clutch is used. The cure is to add or reduce the inertia of other components, usually the flywheel. Yamaha did, for several years, have a wear problem with their [illegible] clutch until it was found to be the lack of total inertia and the problem was cured by adding an inertia wheel to the flywheel. If you feel you have excessive clutch wear, wrong inertia may well be your problem.

Gearing

Contrary to popular belief, changing the gearing does not change the shift speed on a correctly tuned and maintained transmission. The main reason to change the gearing is to obtain the best efficiency from your clutch. If you go back to the efficiency curve in Fig. [illegible] you will find that the efficiency tapers off as you go past a 1:1 ratio. If you have adequate starts, you should concentrate on gearing such that you are at the top of your efficiency curve when you want to be at your top speed on the end of the straightaway. This means you should generally gear on the tall side. Gearing too low is a disaster on top speed because not only do you have less efficiency at the higher ratio but as the transmission stops shifting in high, the motor starts revving and falls off the power curve, with even less power as a result. If in doubt, gear high.

The Belt

[illegible] racing [illegible] the development of drive belts has been amazing in the last [illegible] years. It used to be that broken belts were commonplace and breakage over [illegible] was acceptable to racers.

The earlier belts were made with fiberglass cords which were stiff and had poor adhesion [illegible] rubber. Then a new material called Kevlar or Fiber B started to make inroads. Engineers found that a [illegible] gauge Kevlar cord was just as strong as a 50 gauge fiberglass cord and gave the belts much more flexibility.

The use of Kevlar increased both efficiency and strength and is today the only material used in racing belts. Other such factors as special bonding procedures [illegible] as well as the cog design also influence the efficiency and strength of the belt.

To ensure efficiency and good power transfer it is important that the sheaves which the belt works on is free from grease, oil or rubber deposits and are smooth. Sheaves should be sanded down at regular intervals with a fine grit emery paper to ensure the best working conditions for the belt.

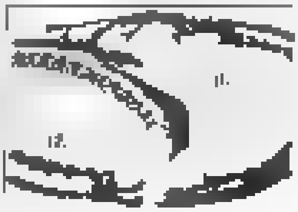
Excessive heat buildup in the sheaves or the air around them adversely affects the strength and the efficiency, and it pays to have the clutch area well ventilated for this reason.

A new belt should be run-in for a short period before it is used for full power. This can be done on a testing stand or during a short easy run. An expert sled racer driver will buy at least half a dozen belts at a time and after run-in, measure the length of the belt. Belts made by the same manufacturer may vary as much as ½" in circumference. Belts of close length are then paired together and the rotating direction and length marked on the belt with a felt tip pen. This insures that once the center distance is adjusted for these belts and you will have more consistency in your selection.

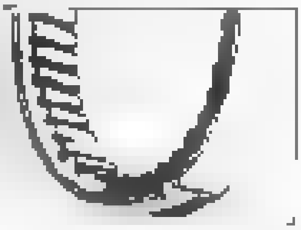
As the sides of the belts wear, it will go further into the driven sheaves in low gear and deeper further out around the shaft of the drive sheave. When this becomes excessive (side wear), the clearance between the sheave and the belt becomes larger before engagement and the position of the belt puts it in a higher ratio at engagement. The result is that the sheaves slam into the belt with a jerking action, but since the system is now in "mid gear" it tends to pull the speed down and bog the machine off the line before it starts to shift out. This can only be corrected by installing a new belt with the correct length and width.

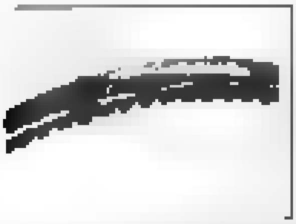
It is important to pay attention to these details, as they may make the difference between winning or losing. Always keep a close eye on the belts condition to spot side cracks, frayed cords or other damage. The pictures on the following pages and the drive belt maintenance chart should give you a guideline to solve any of your belt problems.

[illegible]

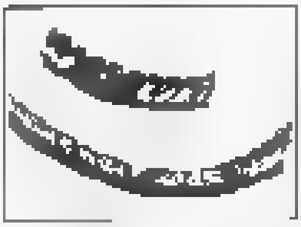


[illegible]





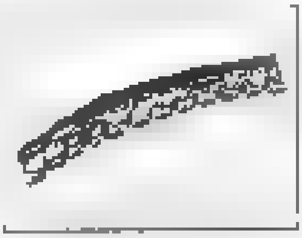
[illegible]
[illegible]



Spin Burn
Caused by excessive slipping of the belt

Undercord Cracking
[illegible]

Severe Sidewall Wear
[illegible]



Edge Cord Separation
[illegible]

Testing

Instrumentation

The tachometer will be your most useful tool when you are working with your transmission. Be sure your tach is of good quality, high accuracy and dependable repeatability. All tachs need to [illegible] from good vibration [illegible] to provide a steady needle that will give a meaningful reading. You have to make sure your tach is calibrated right so that you actually read the correct engine speed, otherwise the whole testing procedure is wasted.

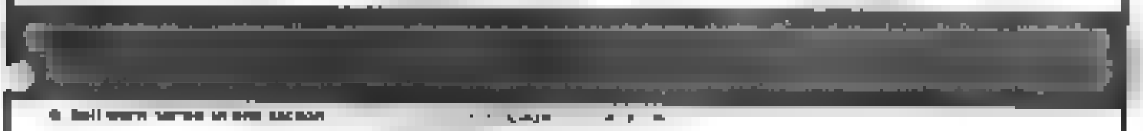
Here is where the factory teams have an advantage. They can calibrate their tachometers with the engine when it is on the dynamometer to make sure they know where the power peak is, and they do not skimp on the money to get the most accurate and rugged tachs available. One of the best tachs available is the Kroeber, which is used by many of the factory teams both in snowmobile and motorcycle racing. To check that your tach is right, there are several alternatives. One of the best is to use a strobotach aimed at a rotating part of the engine and check it against your tach reading. Another alternative is to have it checked by an instrument repair shop, there is usually one in every larger city, and your local car dealer may be able to direct you to one near you.

To check your top speed at the end of your test strip, a speedometer is useful to observe any gain. There are factories that like to use a radar unit to check top speed but this is many times inaccurate and the results should be used with caution.

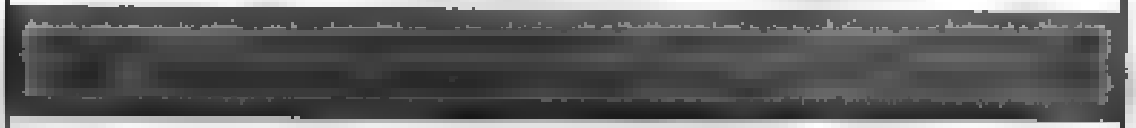
Timing lights are useful if you can afford them. Other useful equipment if you operate

DRIVE BELT MAINTENANCE CHART

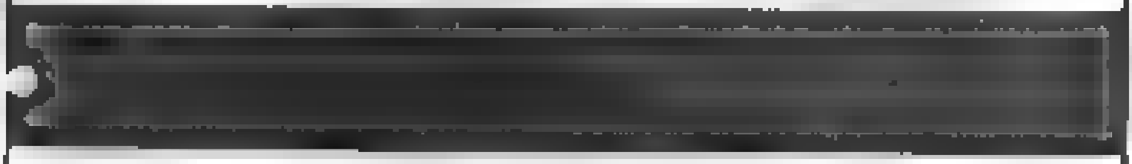
The Problem	Causes	Treatments
1) Belt [illegible]	Sandpaper-like [illegible] caused by: a) [illegible] on belt sides b) [illegible] c) [illegible] pulley [illegible] d) [illegible]	a) Check drive pulley for smooth [illegible] b) [illegible] c) [illegible] and clean pulley surfaces d) [illegible] e) [illegible]



The Problem	Causes	Treatments
6) Belt worn [illegible] in one section	[illegible] a) [illegible] b) [illegible]	a) [illegible]



The Problem	Causes	Treatments
8) [illegible] belt [illegible]	a) [illegible] drive pulley b) [illegible] c) [illegible] pulley [illegible] d) [illegible]	a) [illegible] drive pulley b) [illegible] c) [illegible] d) [illegible] pulley



The Problem	Causes	Treatments
9) Belt [illegible] at high speed	a) Pulley [illegible] b) [illegible] c) E[illegible] on drive pulley d) [illegible]	a) [illegible] b) [illegible] c) [illegible] drive pulley d) [illegible]

The Problem	Causes	Treatments
10) [illegible] between cogs	a) [illegible] belt [illegible] b) Bent pulley [illegible] causing belt [illegible] c) [illegible] d) [illegible] temperature	a) [illegible] belt b) [illegible] pulley c) [illegible] d) [illegible]

The Problem	Causes	Treatments
11) Broken belt	a) [illegible] b) Belt hanging up at bottom of [illegible] pulley c) [illegible]	a) [illegible] b) [illegible] c) [illegible]

with magnetic are a magnetic speed pickup monitoring engine speed and sending via a cable to a chart recorder. This is strictly factory R & D equipment, and not all that practical at the race track. A good tach, trained eyes and ears and a good deal of the pants feeling are many times better tools.

Influence of Engine Performance on Shift Speed

Due to the torque sensing feature of the driven sheaves, the engine output will influence the shift speed. The drive will shift at a slightly higher speed when the engine is cold and has more torque, than when it becomes warm and loses some power. To compensate for this, make sure you make all your tests when the engine is warmed up. Also make some test runs on race day if possible, because the engine will produce more power on a warm or cold day and this may have to be compensated for. Changes in altitude will also change the shift speed as the engine loses power at higher altitudes and a recalibration may be necessary.

Test Area

To test your transmission, you need a test area. What you should look for is a flat straight piece of land which will permit you to make a run of at least 1/4 mile. The best procedure consists of a drag run from standing start while you keep one eye on the tach. Since you will be watching the tach most of the time it is important that there are no obstacles in the area that can get you in trouble.

Procedure

1. Find out at what engine speed your engine is supposed to operate at maximum performance.
2. Establish what approximate engagement speed you want to run.
3. Draw a speed diagram with the above information for your reference during testing.
4. Make sure all parts of the transmission are working freely, that the transmission has the correct alignment and that you are using a good drive belt.
5. Make sure you are using the recommended ramp and [illegible] for best efficiency.
6. Make notes of what exact parts are in your transmission before testing.
7. With the vehicle standing still, increase the engine speed until the vehicle starts moving, and note the engagement speed.
8. Make some runs to warm-up the engine.
9. Make four full speed runs or more from a standing start and observe where the transmission starts shifting out, and the shape of your shift curve. Does it hold the engine at a constant speed from approximately 30 MPH, or do the RPM's increase or decrease as the transmission shifts out.

0. Compare the tach readings with the desired shift curve and make the required judgement of what variable to change in the driving clutch to approximate the desired curve. Use the earlier chapters for reference. First get the approximate weights and springs for your desired engagement speed and shift speed, then find the combination of shift cam that gives you a straight shift, then fine tune the weight of the flyweights to give you the correct shift speed. Change only one item at a time and make notes of your changes as you go along.

1. When your clutch is tuned right for the particular given driven settings, time yourself for several runs.

2. Now experiment with a different driven setting and go through another tuning procedure to match the driver for this setting. Then use this new combination to see if you have gained in performance, compared to the previous setting.

3. When you have established your best driven combination for efficiency, also try some higher and lower shift curves to establish if the power curve on your particular engine differs from the given information. (Try 250 and 500 RPM below and above the point where your power peak is supposed to be.

This is basically the procedure the factory racers go through and it takes a lot of time and patience. After some testing you will become familiar enough with your unit to get a good feel for the variables, and be able to come close to the desired result fairly quickly.

Summer drag racing is an excellent place to learn the basics about clutches because the testing procedure is practically a drag race.

There is no substitute for testing, and those who do their homework will have a better and more efficient transmission working for them.

Polaris

The Polaris clutch system is quickly gaining popularity and reputation as the "hot set-up" for racing. This reputation is well earned as their clutches have a number of outstanding features, and generally has shown a higher efficiency through the shift range and particularly at top end. This all translates into more power to the ground.

It is hard to put the finger on exactly what component is responsible for the good efficiency, but more than likely it is a combination of all the design factors being proportioned together correctly. It is not advisable to adapt only part of the system to your machine as any combination may lose you efficiency and power.

If you want to do it right, use all Polaris components, both drive, driver and their belts. The conventional driver can be used successfully for racing but the RXL driver has several features which come in handy when racing. These features include a spider which is mounted on a spline rather than screwed on. This makes it possible to remove the whole moving sheave assembly and switch it for another one with different settings between races by only removing the center bolt. The racing clutch also has adjustable engagement speed and the movable sheave can be spaced to keep a .020" clearance with the belt by use of spacer rings between the spider and the shaft.

The driven sheaves also have a selection of ramps including 30, 32, 34, 36 and 40° which make it easy to tune these clutches to almost any engine size. The flyweights also come with two different curvatures, one for a mildly tuned stock motor and a different curvature for race motors.

We highly recommend that the racing weights be used for modified engines. For a selection of weights see the weight chart. There is also a good number of springs available with a selection of pretensions and spring rates. Between the flyweights and the springs and a selective amount of grinding on the flyweight area the Polaris clutches offer a "tunability" that is not easily duplicated by other brands. The following information for the RXL clutch is provided to illustrate the tuning features of the racing clutch.

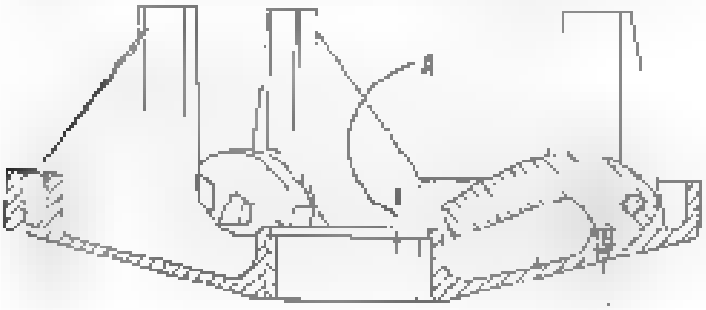
CLUTCH TUNING

Drive Clutch Engagement RPM Adjustment: The RXL drive clutch [illegible] speed [illegible] determining of the three shift weights [illegible]

Before the clutch is [illegible] the position of the spider rollers and shift weights must be checked to ensure they are all equal. [illegible] to a reference point on the [illegible] Fig. 2-6.

The engagement should be as low as possible without stalling the engine [illegible] RPM. [illegible] the engagement [illegible] will have [illegible] chance to break [illegible] and initial acceleration off the starting line will be [illegible]

To adjust the engagement RPM, [illegible] all three adjusting screws in or out an equal amount. [illegible] the [illegible] will decrease the engagement and [illegible] the screws out will increase the engagement RPM (Fig. 2). NOTE: [illegible] of the clutch is decreased and further adjustment may be required.



Adjustment of Clutch Neutral Position [illegible] the movable sheave [illegible] the drive [illegible] weight [illegible] (Fig. 3). [illegible] movable flange [illegible] the washer under the spider.

The [illegible] washers [illegible] the spider. The [illegible] thickness and [illegible] numbers [illegible] the following [illegible]

[illegible]	55 [illegible] 40
[illegible]	[illegible]
[illegible]	[illegible] 40
[illegible]	[illegible] 40

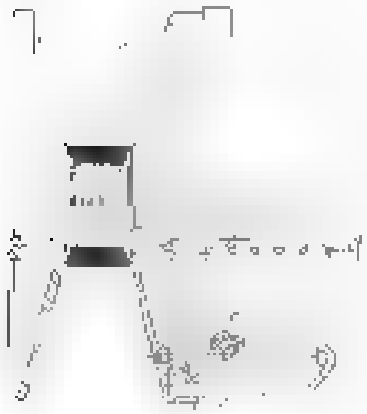


Fig. 3

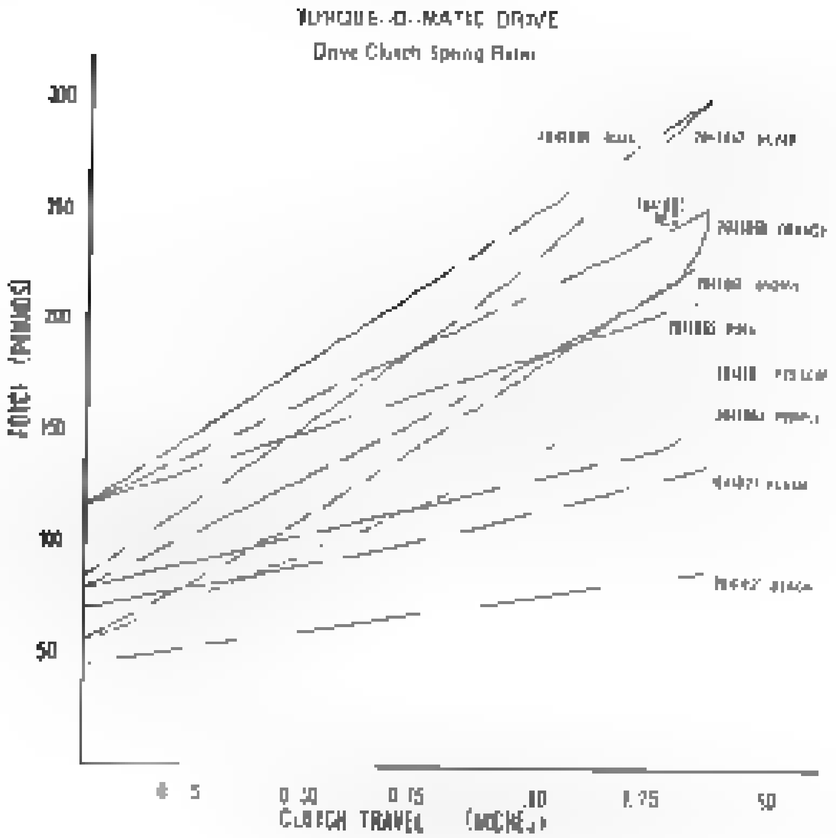
[illegible] Engagement and Neutral Position [illegible]

When [illegible] the movable [illegible] belt [illegible] [illegible] may be [illegible] [illegible] [illegible] will [illegible]

[illegible]

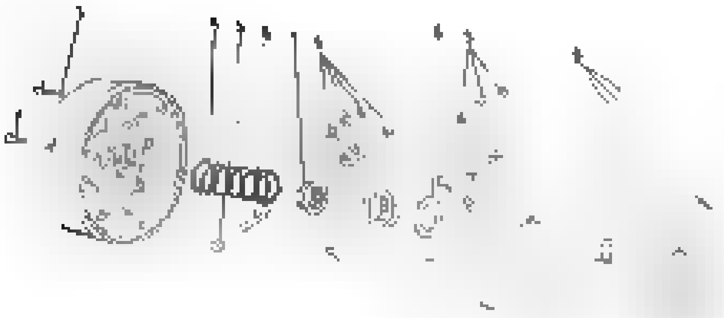
POLARIS FLYWEIGHTS FOR 197[illegible] THROUGH 1980

Identification No.	Weight in Grams ± 1.0 Gram	Polaris Part No.
	Stock Flyweight Available	
00'	53	5630134
0	50.5	5610050
A	47.5	5610060
B	43	5610064
C	41.5	563006[illegible]
E	40	5630[illegible]7
J	37.5	5630109
K-1'	37.5	5630128
F'	35	5630139
O	30	5630107
	Racing Flyweight Available	
M'	54	5630060
H	50	5630063
M'	47	5630068
P'	42	5630069
K-1	40	5630144
Q-1	38	5630146
R-1'	36	5630147
S-1	34.5	5630145
L-1 Ground	33.5	5630177
T-1	32.5	5630148
E-1'	29.5	5630151



TORQUE-O-MATIC DRIVE

Drive Clutch Spring Rates



197[illegible] MODEL CLUTCH AND DRIVE DATA

[illegible]

1978 MODEL CLUTCH AND DRIVE DATA

[illegible]

1979 MODEL CLUTCH AND DRIVE DATA

[illegible]

Comet

The Comet clutch system is manufactured by Hoffco Industries in Richmond, Indiana. Hoffco is the lone U.S. survivor as a supplier of drive systems to the snowmobile and accessory industry. This is undoubtedly due to their flexibility and good product quality. The most popular clutch for the performance minded individual is the 102C series. This unit is not unlike the Polaris clutch with three flyweights working against rollers mounted to a star or spider. The torque transfer point is located on the spider towers where plastic buttons slide against flats in the movable sheave. With a good assortment of springs and flyweights available, the Comet clutch has been a good choice for many drivers and in the 70 and 71 race seasons it also saw extended use by the Arctic Cat and Ski-Doo factory teams.

On the following page is a grouping of the flyweights presently available for the 102-C and [illegible]. Comet starts out with a number of base weights such as B, C, D, F, H, K, M, X and A-1. By machining these weights to be lighter or by machining a flat or half-moon in the engagement area for a modified or aggressive take-off, a group of flyweights are formed.

Comet also offers two different cam shapes on the flyweight, a normal radius for most machines and a more aggressive smaller radius for the special applications. The flyweight group, base part number, thickness, weight, engagement profile and cam profile are all listed to aid you in selection of the correct flyweight for your application. Examples of some of the configurations are shown as well as information on the pressure springs available.

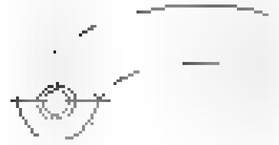
The driven unit has three basic ramps available, 77°, 56° and 5[illegible]°, and 2 or 3 springs with different tensions. Red is stock and an orange spring No. [illegible] with 35% more tension is available as a special part. Spring tension on the driven unit can be varied by using any one of 4 mounting holes and by rotating the movable sheave on the cam 30°, 60° or 120°. (See chart for desired tension)

PRE-TENSION AND CALCULATED RATES OF POPULAR PRESSURE SPRINGS

Spring Color	Part No.	Wire Size	Coils	O.D.	Pre-tension at 2 3/8	Rate
Red	203839	167	6	2	15 lbs	44 lbs/in
Pink	203971	177	5	2	42 lbs	40 lbs/in
Blue	201287	177	6	2	47 lbs	140 lbs/in
Black	2041	167	5	2	74 lbs	[illegible] lbs/in
[illegible]	[illegible]	167	4	2.06	[illegible] lbs	[illegible] lbs/in

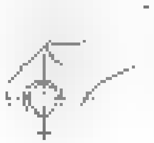
[illegible] CAM ARM CONFIGURATION

Group	Arm	Part #	Engagement	Thickness	Weight	Cam Profile
[illegible]	B	20[illegible]069	Normal	25 6.35	40.[illegible]	Normal
E	H	203906	Aggressive	2[illegible]	33	Normal
[illegible]		203892	Normal	2[illegible]	4[illegible]	Normal
[illegible]	B	20[illegible]	Modified	25	44	Normal
C	HB-	205395	Aggressive	25	4[illegible]	Normal
C		203680	Normal	2[illegible]	[illegible]	Normal
[illegible]	[illegible]	204247	Modified	[illegible]	4[illegible]	Normal
C	B-1	207422	Modified	24	41.[illegible]	Normal
C	[illegible]	207400	Modified	24	3[illegible].[illegible]	Normal
C	B-2	207437	Modified	24	3[illegible].0	Normal
D	B	202550	Normal	25	44.0	Aggressive
D	[illegible]	20380[illegible]	Modified	25	4[illegible].[illegible]	Aggressive
F	F	203092	Normal	35	5[illegible].[illegible]	Normal
F	HB-	203063	Modified	35	5[illegible]	Normal
F	HB-1	203397	Normal	3[illegible]	[illegible]	Normal
F	I	205137	Aggressive	35	46.0	Normal
U		20[illegible]	Normal	34	6[illegible].5	Normal
U	[illegible]	20[illegible]5	Modified	34	62.0	Normal
	G	2069[illegible]	Aggressive	36	5[illegible].0	Normal
G	J	205243	Normal	36	5[illegible].[illegible]	Normal
G	B-1	201676	Normal	36	57.5	Normal
H	J	20[illegible]270	Aggressive	36	5[illegible]	Normal
H	HB-4	206995	Modified	36		Normal
J	N	205237	Normal	32	5[illegible].5	Aggressive
K	K	20[illegible]370	Normal	31	[illegible].0	Aggressive
K	HB-5	207818	Modified	31	48.5	Aggressive
[illegible]	[illegible]	207689	Normal	32	40.5	Extra Aggressive



Normal Engagement

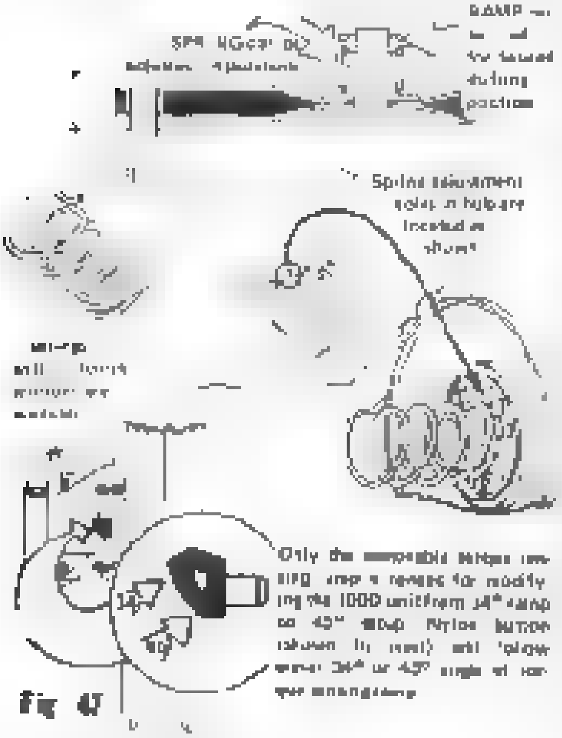
Modified Engagement



Aggressive Engagement

MODIFYING AND ADJUSTING THE 1000 OR YEN UNIT

The illustrations shown here are for reference only. They are provided here to [illegible] more graphically the modification and adjustment of the 1000 Driven unit.



Only the moveable torque sensing ramp is remade for modifying the 1000 unit from 34° ramp to 45° ramp. Nylon button (shown in insert) will allow either 34° or 45° angle of torque arrangement.

fig 47

ADJUSTING THE SPRING TENSION OF THE 1000

Note: By increasing the spring tension of the torque sensing system [illegible] the driven unit [illegible] will [illegible] higher engine [illegible] before it [illegible] to [illegible].

Shown [illegible] the [illegible] for the driven [illegible] [illegible] [illegible] the amount of spring tension [illegible] allow the [illegible] the driven unit [illegible].

[illegible] removed from the unit, then [illegible] the [illegible] this.

POSITION OF SPRING TENSION DESIRED	USE SPRING HOLE AS SHOWN	ROTATE MOVEABLE SHEAVE AS SHOWN	MOVEABLE SHEAVE WILL ROTATE BACK AS SHOWN
D	4	10°	30°
5 D	3	40°	20°
4 C	2	20°	90°
B		130°	80°
8 A	6	45°	30°
6 F	7	30°	90°

This is an approximate measurement of resistance [illegible] that will be realized from the [illegible] of the sheave diameter.

ADJUSTMENT INSTRUCTIONS FOR 1000 UNIT

STEP NO. 1

If possible, [illegible] the driven unit [illegible] the [illegible] place the [illegible] with the movable sheave in [illegible] on a table or bench and secure the fixed sheave by having someone hold it by some means. [illegible] DAMAGE [illegible] TO [illegible] UNIT.

STEP NO. 2

[illegible] the movable sheave [illegible] the [illegible].

STEP NO. 3

[illegible] spring [illegible] the desired [illegible] of the [illegible].

STEP NO. 4

[illegible] the [illegible] of the fixed sheave [illegible] engage the [illegible] of the [illegible].

STEP NO. 5

Holding the fixed sheave [illegible] rotate the movable sheave [illegible] the number of degrees desired according to chart.

STEP NO. 5a

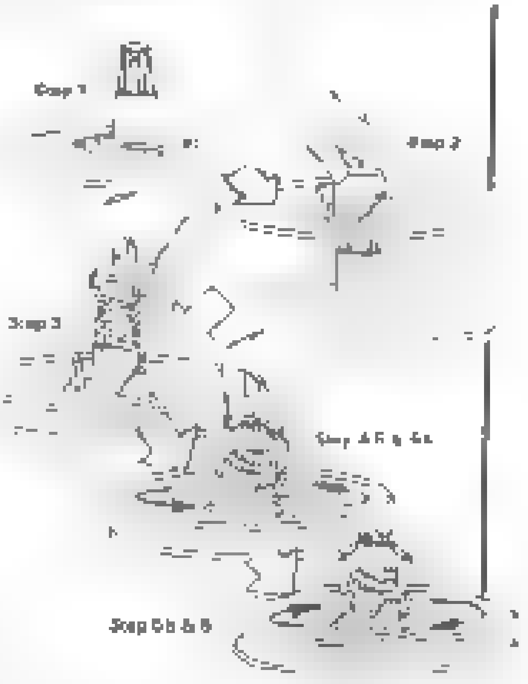
Hold the movable sheave [illegible] and [illegible] down to engage splines completely. [illegible] will have to be below the groove [illegible] for [illegible].

STEP NO. 5b

Insert two piece snap ring into slot provided on splined [illegible].

STEP NO. 6

Allow movable sheave to [illegible] operational position. [illegible] number of degrees the sheave will rotate with each setting.



Yamaha

The Yamaha SRI clutch design follows in the footsteps of the Polaris and [illegible] clutches as far as basic design. It has flyweights working against rollers in the spider tower. The torque transfer buttons are on separate arms of the spider. The clutch has several nice features. The flyweights have 3 holes in them, and by adding rivets to these holes, you can change the weight of the flyweight. Depending on where you add the rivets, you can also concentrate the pressure towards the lower or higher part of the shift curve. The spider is mounted on splines which make it possible to take the whole movable assembly off and put on another one with lighter or heavier weights just as with the Polaris Pace clutch. Another nice feature is the sliding bushings which are mounted solidly in their housings, thereby making it difficult to misalign the bearings and wedge the floating assembly on the shaft.

There are two driven assemblies that can be used with this clutch. The SRI clutch has two ramp angles available. One ramp is a straight 42 degrees and the other has a double angle 37 to 43 degrees. The wider GTX driven clutch is more popular for modified use. This clutch has the ramp at a larger radius and since the leverage ratio then is reduced, the ramps come with 33° or 27°. These ramps give the same result as the steeper ramps on the SRI driven clutch.

The SRI has somewhat unjustifiably gotten a reputation for poor reliability. Recent development has however pointed to insufficient flywheel mass as the culprit. This lack of weight caused high frequency vibrations in the clutch which then would wear out the bearings. Yamaha now has a kit for this problem, an extra flywheel that can be bolted on the flywheel itself to increase its mass. This takes care of the wear problems and should give future owners substantially better service from this clutch.

[illegible] a new rivet in the [illegible] the weight and peen over the other end.

CAUTION: Check the weight [illegible]

PRIMARY SPRINGS, SRX, EX AND GPZ listed in order of spring rates

PART NUMBER	SPRING CONSTANT	PRELOAD	COLOR	WIRE DIA	OUTSIDE DIA	NUMBER TURNS	FREE LENGTH	
90501-50153-00	40	[illegible]	ye-grn	4.0	54	[illegible]	91	[illegible] rpm
90501-[illegible]236-00	50	65	[illegible]	5.5	54.5	6.5	104.8	[illegible] GYT kit
90501-[illegible]461-00	1.?	25	blu-pink	5.5	54.5	5.8	75.?	SRX opt 4,000 rpm
90501-[illegible]844-00	[illegible]	30	[illegible]	5	55	6	79	[illegible]
90501-[illegible]543-00	[illegible]	30	[illegible]	5.5	55	5.8	78.4	SRX opt 4,000 rpm
90501-[illegible]529-00	[illegible]	5	[illegible]-pink	5.5	55	5.8	81.5	SRX[illegible]/433 std
90501-[illegible]403-00	1.?	40	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	45	red-grn	[illegible]	55	[illegible]	[illegible]	[illegible] part
[illegible]	[illegible]	[illegible]	[illegible]-pink	5.5	55	5.8	92.2	Tuning part
90501-55[illegible]-00	[illegible]	42	[illegible]	5.5	55	5.5	84.8	[illegible] 5,000 rpm
90501-[illegible]-00	1.90	47	org-wht	5	55		56	[illegible]
90501-5[illegible]-00	2.?	[illegible]	brn-wht	5	[illegible]	4	[illegible]	[illegible]
90501-[illegible]-00	2	3?	[illegible]	[illegible]		[illegible]	[illegible]	[illegible] std.
90501-55467-00	2.0	50	red-org	5.5	54	[illegible]	[illegible]	[illegible]
90501-55[illegible]-00	2.0	60	red-org	5.5	[illegible]	[illegible]	91	[illegible] GYT kit
[illegible]	2.?	64	[illegible]	5.5	55	5.4	93.5	[illegible] GYT kit
90501-50396-00	[illegible]	20	grn-wht	5.0	55	4.?	71.5	[illegible] std
90501-5[illegible]465-00	2.55	[illegible]	red-red	5.5	[illegible]	[illegible]	[illegible]	[illegible]
90501-55[illegible]97-00	2.[illegible]	[illegible]	red-[illegible]	5	[illegible]	4	[illegible]	[illegible] std
90501-[illegible]03-00	2.40	41	blu-wht	5.5	54.5	4.9	96.2	[illegible]
90501-5[illegible]485-00	2	30	brn-wht	5	55	[illegible]	91	[illegible] approved

SECONDARY SPRINGS

90508-4[illegible]-00	4.?3kg-m/deg	blue	4.5	64.5	9.?5	20mm	[illegible]
90508-4[illegible]-00	0.8?kg-m/deg	[illegible]	4.5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] kg-m/deg	yellow	4	[illegible]	[illegible]	[illegible]	[illegible]
90508-4[illegible]	[illegible] kg-m/deg	white	4.0	64.5	9.05	85mm	[illegible]

CLUTCH WEIGHT		[illegible]
8?7-17632-[illegible]-00	Stock 440	Moderate engagement [illegible] slightly [illegible]
[illegible]	[illegible]	Moderate engagement [illegible]
[illegible]	[illegible]	Extreme engagement [illegible]
8?7-17632-?0-00	Mod. [illegible] 440	No engagement [illegible]
8?7-17632-00-00	EX 340/440	No engagement runaway very heavy
[illegible]	[illegible]	Extreme engagement runaway

There are two (2) ramp sets available for the secondary clutch, they are:

PART NUMBER	RAMP ANGLE
8?5-17684-[illegible]-00	4? degrees
8?7-17684-[illegible]-00	3?-45 degrees

Rollers

12mm diameter 90387-06606

14mm diameter 90387-06550

SPRING SHIM— 90214-30614

Clutch Weight Rivets

[illegible] weights [illegible]

[illegible] weights 90?91-0?015

Arctic Cat

As this is written, Arctic Cat is in the process of developing a new line of clutches, presumably based on the Polaris and Comet designs. We will, however, take a look at the Arctic hex bushing clutch, as it is still very popular as a performance clutch, especially in drag racing. The popularity is due to the easy tuning of this clutch. The torque is transmitted through the bushings in the sheave and cover of the floating assembly. The spider only holds three sets of arms with rollers and weights mounted on them. These rollers roll against cams fastened to the movable assembly. This makes it possible to work on the ramp configuration first to get a straight shift and a desirable engagement speed. Fine tuning to get the exactly correct shift speed is then accomplished by changing the weights on the roller assembly.

There are a number of roller and arm assemblys available. For modified engines working at higher RPM, only small rollers and light stamped arms should be used. For slower turning motors, cast arms and larger rollers are used. Arctic has available a blank ramp, part number 0146-257, for the purpose of grinding custom ramps. A ramp holder should be used when you grind the ramps to make sure all surfaces [illegible] the present [illegible] in the clutch. Small differences in ramp contour can give large differences in RPM and shift patterns.

A number of springs are available for the Arctic clutch to [illegible] engagement speed and [illegible] tension. In addition to the springs in the chart, [illegible] a "Gold" spring. This spring has the same rate as the green spring but an 8 lb. pre-tension for higher engagement speed. Also available is a set of weights from [illegible] to 10 grams [illegible] gram steps, a ramp grinding block, and extra long high [illegible] bushings.

CLUTCH RAMPS AVAILABLE FROM ARCTIC ENTERPRISES

Part No.		Part No.
0146-[illegible]	35	0146-[illegible]
0146-[illegible]		0146-[illegible]
0146-025	5	0146-[illegible]

	Part No.	Spring Rate (lb/in.)	Spring Comp. @ .75 in.	Spring Length (No Load)	No. Coils	Color Code
Lower	[illegible]	[illegible]	[illegible]	[illegible]	6	White
	0146-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Red
	0146-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Yellow
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Higher	[illegible]	[illegible]	[illegible]	[illegible]	5.0	Green

CLUTCH RAMP CONTOUR VARIABLES

Figure 1 [illegible]

Figure 2 Ramp holds flat [illegible] ramp [illegible] RPM with the same weights and spring.

Figure 3 Ramp [illegible] speed [illegible] spring.

Figure 4 Ramp [illegible] engagement speed [illegible] weights and spring.

CLUTCH WEIGHTS AVAILABLE FROM ARCTIC ENTERPRISES

	Part No.	Rivet Diameter	Mass Grams	[illegible]	[illegible]
Light	0116-[illegible]	[illegible]	[illegible]		
	0116-[illegible]	0.16	[illegible]		
	0116-[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]			
	0116-[illegible]	[illegible]			
	0116-[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]			
	[illegible]	[illegible]	[illegible]		
	0116-[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0116-[illegible]	[illegible]	[illegible]		[illegible]
	0116-[illegible]	[illegible]	[illegible]		
	0116-[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
Heavy	0116-[illegible]	[illegible]	[illegible]		

Kawasaki

In 1975, Kawasaki introduced their own [illegible] [illegible] [illegible] and a [illegible] drive clutch system. This clutch has three flyweights mounted on a "spider" working against rollers on the movable sheave assembly. The torque transfer point is on separate arms on the spider that works against plastic inserts in the movable sheave. The flyweights start out at a 9 o'clock position and swing up to a 12 o'clock position as the drive shifts up. Weights can be calibrated separately as the flyweights have a mounting position for bolts which can be stacked with washers. Four [illegible] weights are listed [illegible] table.

Because of the [illegible] curve of the flyweights, it is harder to change the shift curve than on conventional flyweights, especially since [illegible] out that [illegible] adding [illegible] would be the ideal procedure.

The engagement speed is easy to change, however, by grinding the engagement area of the tip of the weight more parallel with the crankshaft as shown [illegible] drawing.

1975 models came with a [illegible] weight. This weight was not heavy enough [illegible] and [illegible] over to high range with a quick [illegible] [illegible] In 1976 Kawasaki [illegible] weights were narrower [illegible] weight [illegible] 0.5 which reduced the drag and gave some increase in top end.

The 1975 clutch had roller assemblies with excellent nylon-coated bearings. [illegible] Kawasaki changed these and took out the nylon bearings. These new [illegible] and it is recommended to use the older 75 rollers [illegible] better wearing. The Kawasaki driven [illegible] is also a well designed unit with [illegible] There are three notches in the movable sheave and [illegible] the cam for the [illegible] spring [illegible] changing [illegible] A 35° ramp is standard, but a 40° ramp for higher [illegible] is also available.

NOTE: [illegible] engagement and RPM [illegible] [illegible] See chart below.

Kawasaki Springs

Color	Free length, mm	Lbs. at [illegible] mm
Yellow	130.5	144
Br[illegible]n	[illegible]2	5[illegible]
Black	1[illegible]0.1	[illegible]
White	20.4	86

Kawasaki Flyweights

Ramp	Weight	Configuration
C	51.7	Original 16 weight, aggressive start, light on top end
G	50.7	Same as C but lighter
E	47.5	19 ramp, [illegible] weight, used with heavier [illegible] 2, faster top end
F	46.5	Ramp more [illegible] beginning, good top end

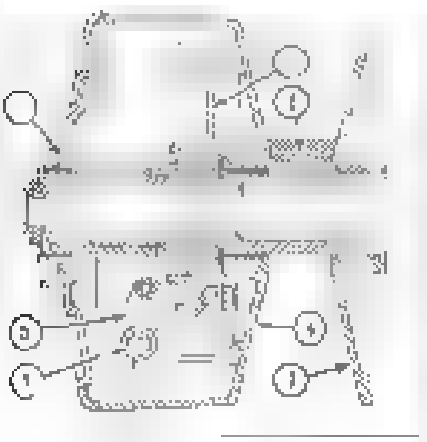
Calibration Weight Information

Thick washer 6 grams Thin washer [illegible] grams Nut 2.4 grams

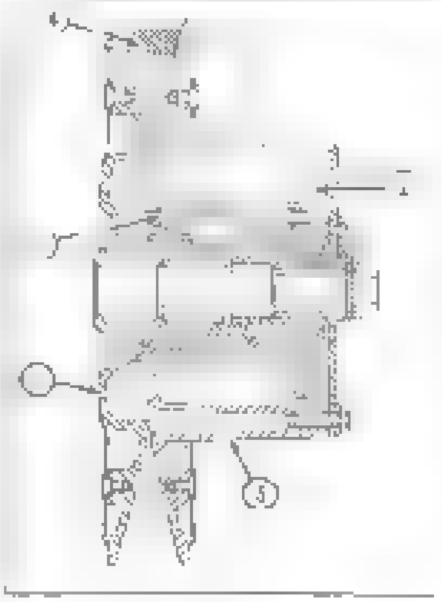
Bolts

Aluminum 20mm 2 grams Aluminum 15mm 1.5 grams Steel 25mm 7.9 grams

Steel 20mm 6 grams Steel 16mm 5.3 grams



1 Roller
2 Spider Assembly
3 Spring
4 Movable Sheave
5 Weight Ramp
6 Drive Belt
7 Stationary Sheave



1 Spring
2 Ramp
3 Movable Sheave
4 Drive Belt
5 Stationary Sheave

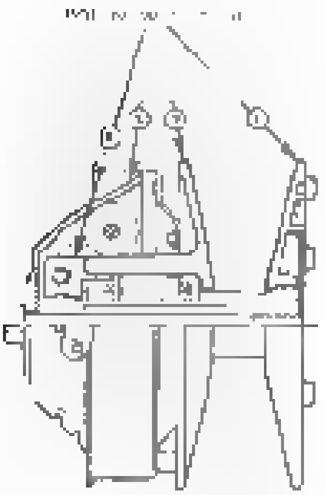
Ski-Doo

Ski-Doo has had their square bushing clutch available for a number of years. Like the Arctic clutch, the torque is transferred through a bushing on the shaft, this one square instead of a hex as on the Arctic. The original square bushing clutch had arms with rollers that acted as fly-weights. The rollers moved against a curved cover, and the curve of the cover would give the desired shift force. Once the cover was stamped it was hard to change, which gave little possibility of fine tuning for racing.

Ski-Doo went a step further and improved on the tunability of the clutch by mounting three ramps in the cover. These ramps could be ground to different configurations to give higher engagement or more correct shift speed. These clutches are still in use on many Ski-Doo models although the racing team has changed to Comet clutches because of the improvements in machining and response this clutch gives over the square bushing design.

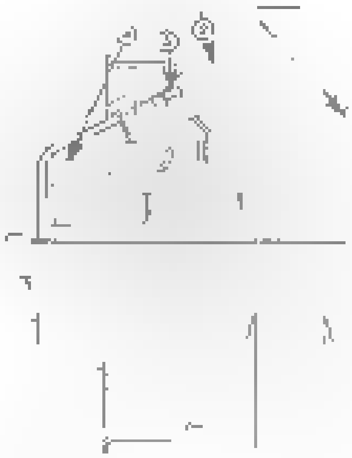
The dimensional design unit is of a good quality design with interchangeable ramps and springs and should be considered for performance machines.

Rollers against cup



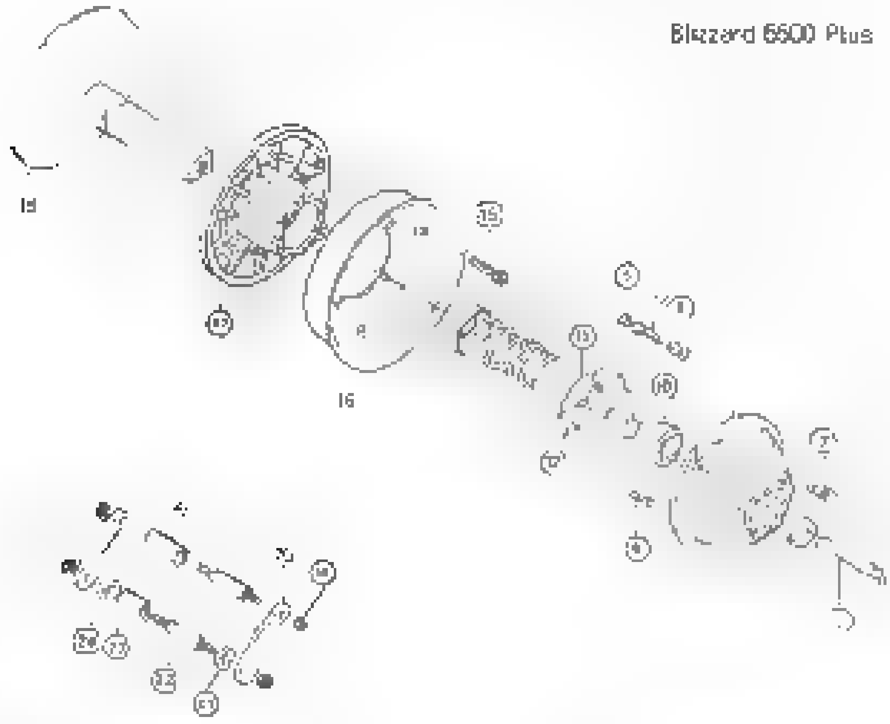
[illegible]

Rollers against ramp



SQUARE SHAFT WITH THREE COUNTERWEIGHT ASSEMBLIES

Blizzard 6500 Plus



[illegible]

25 Bushing

TRANSMISSION TUNING DATA

Date ____________ Sheet No ____________ Test Track ____________

Surface Conditions ________________________________

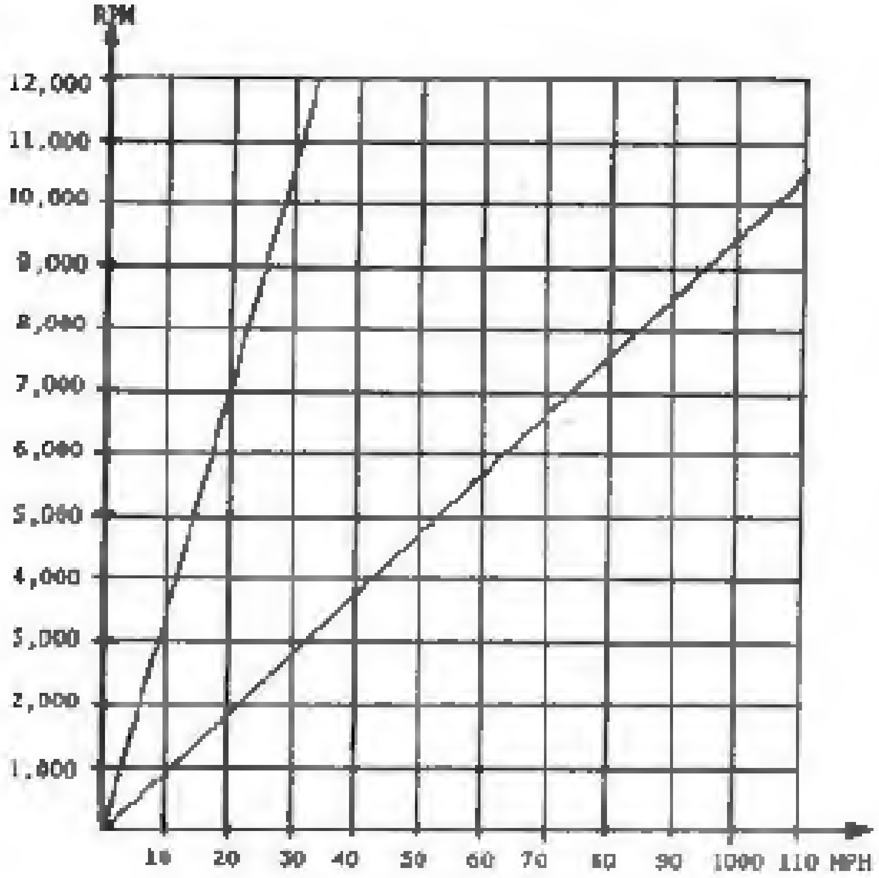
Vehicle Type ________________ Transmission Model ____________

Center Distance ______________ Gearing ____________________

ITEMS	Test 1	Test 2	Test 3	Test 4
DRIVEN				
Ramp Angle				
Spring Designation				
Pretension				
DRIVER				
Spring Designation				
Flyweight Designation				
Shift-Cam Surface				
BELT				
Brand				
Length				
SHIFT INFO				
Engagement Speed				
Shift Speed				
Over-run in Low				
Shift Speed Increase				
Shift Speed Decrease				
Average Time of 6 runs				
Comments				

SPEED DIAGRAM

ENGINE SPEED VS. VEHICLE SPEED



ENGAGEMENT SPEED = ______________ RPM

SHIFT-SPEED = ______________ RPM

DRIVER

PRESSURE SPRING ______________

FLYWEIGHT ______________

DRIVEN

RAMP ANGLE ______________

PRETENSION ______________

notes

32 g

Fjäder skruv
114 mm

Reserv 32,5 1117 mm längd

414-3558

"Our Reputation Is At Stake"

[illegible] YEARS IN BUSINESS

It may not seem like a lot, but in the performance business, where new companies fold as soon as their first good idea got outdated, it is a milestone worth considering. We have grown because we stress development of new products to stay ahead of the crowd and at the same time build these products with the quality that is demanded by todays snowmobiler.

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Getting the power is only half the story, getting it to the ground is the other half. That is why we complement our products with extensive instructions on any changes required to get the most out of the machine, like jetting, clutching, and gearing. We also offer a full line of traction products to make sure you hook up, like the innovative Kickon stud which mounts directly under the slide rail and instantly became the hot setup for factory racers and drag racers alike when it was introduced three seasons ago.

Our research and development never stops, and that is why you will see our name at local grass and ice drags and at international Sno-pro races testing and developing new ideas. No matter how much engineering and testing is done on the dyno, the final test is how well it works on the track and that's why we stay involved. With us the phrase "racing improves the end product" is not just a slogan, it's a hard fact and benefits you directly no matter what level of performance you seek.